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Forecasting for the construction and tow of the Ninian Field Platform

By O. M. Hull

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Summary

The weather forecasting problems involved in the construction of a massive concrete drilling platform off north-west Scotland and its towing to its operational position in the North Sea oilfield are described, as is the successful overcoming of these problems by the establishment of a special local forecasting office.

A new task for the London Weather Centre

For many years now the London Weather Centre has been involved in forecasting for the North Sea Oil industry, but in 1977 we first became involved in the tow-out and positioning of production platforms. After exploratory drilling has established the existence of an undersea oil field, and the exact position from which it can best be tapped, the test well-heads are sealed off and the sea bed is cleared for the construction of a production platform. From the production platform a number of new wells will be sunk into the oil-bearing strata, and a pipe-line or loading buoy will be attached to get the crude oil ashore.

In the deep water of the northern North Sea there are two types of production platforms in use. Steel platforms consisting of a framework of huge steel girders taller than the water depth, say 200 metres, are floated over the field and stood upright over the spot chosen for drilling. The difficult and weather-sensitive task of pinning the platform to the sea bed with huge piles must then be completed before the superstructure of pump rooms, drill equipment, accommodation and helicopter deck, is lifted and built into position—a very slow job in a rough stretch of water. Concrete platforms, on the other hand, consist of vast and complicated concrete towers, which are floated in sheltered bays during the construction phase, then towed out to the chosen locations and sunk. Their own weight and vast base area make piling unnecessary and, since the superstructure is in position when they leave harbour, these platforms are almost ready to start drilling and be coupled to the pipe-line as soon as they hit the sea bed. Positioning on the drilling site is a much less weather-sensitive operation than for steel platforms, but calm conditions are necessary for the critical operation of fitting the superstructure into position on the platform.

Most concrete platforms for the North Sea have been built in the deep but sheltered waters of the Norwegian fjords; however, Chevron Petroleum had their Ninian Field platform built by Howard Doris Ltd at Loch Kishorn on the west coast of Scotland, just east of the Isle of Skye (see Figures 1 and 2). The base of the platform, about the area of Trafalgar Square, was built like a huge washing-up bowl in a specially constructed dry dock and then floated into Loch Kishorn. As the construction continued, the structure sank deeper in the water and for the final stages of the work it was moored in very deep water at the southern end of the Inner Sound of Raasay.

Howard Doris had set up a forecasting office to assist in the construction phase, using a French forecaster and two assistants. The office was equipped with radio-teleprinters and radio-facsimile receiver.

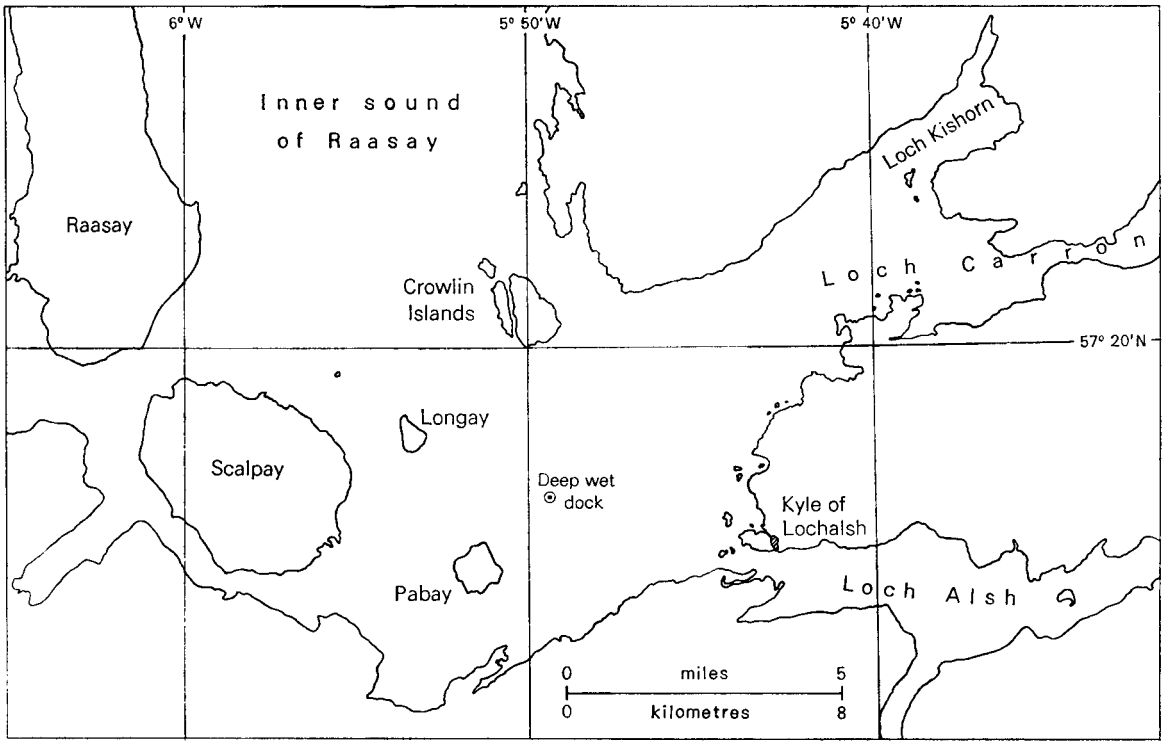

Figure 1. Location of deep wet dock with respect to Loch Kishorn and Loch Alsh.

The tow to Loch Kishorn

In October 1977 Chevron Petroleum approached the London Weather Centre to provide an 'on-site' forecasting service for the mating of the concrete base and the steel superstructure, which would hold most of the engineering and accommodation. The first task was towing the superstructure from its construction site at Ardersier, near Inverness, through the Fair Isle channel to Loch Toscaig

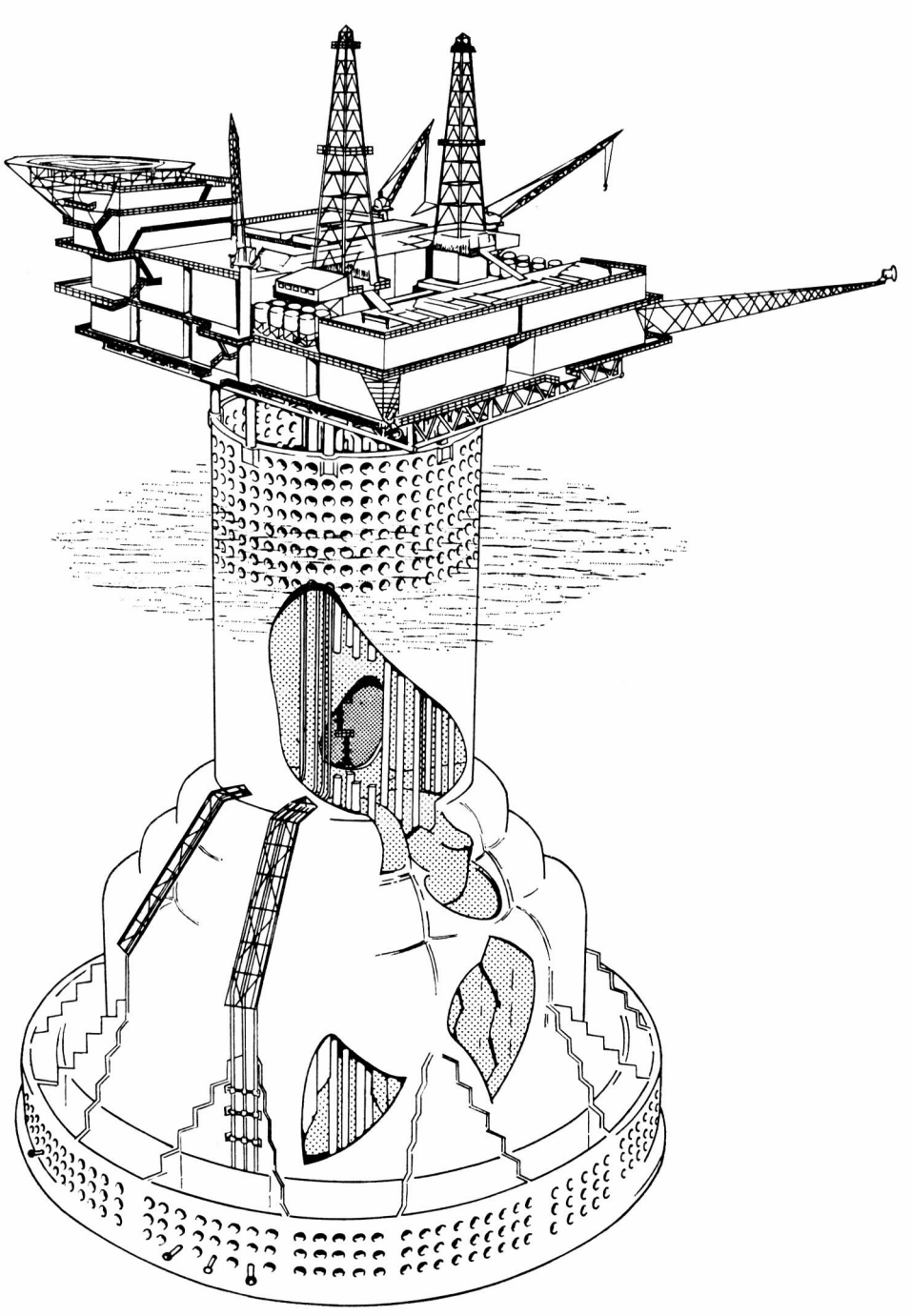

Figure 2. The Ninian Field Central Platform (reproduc d by permission of Howard Doris Ltd).

near Kishorn. The forecast for this operation was provided by the London Weather Centre and started on 19 October 1977. The two-and-a-half-day tow was completed during a short 'weather window' between two autumnal depressions, and the tow arrived off Loch Toscaig on 9 November.

Transfer from barge to catamaran

Two forecasters from the Weather Centre were at Kishorn when the tow arrived, and by snatching every moment when fair weather was forecast the engineers jacked the huge superstructure off the towing barge and secured it on a catamaran barge whose pontoons were wide enough to straddle the top of the concrete base. This work was completed on 11 November and the catamaran was moored in the sheltered waters of tiny Loch Toscaig.

A new forecasting office

For the mating of the base and superstructure a flat calm was required for 48 hours and about five days' warning of the calm was needed to mobilize all the necessary staff and facilities into this remote part of Scotland. A forecasting office had been set up at the Chevron office. Chevron provided a barometer, and an anemometer which was very badly sited at the top of a cliff and on the south side of a 2500 ft hill; but in that wild country there are few good anemometer sites, and the readings from Loch Kishorn bore little relation to the readings from the anemometers on the structure floating in the Inner Sound. There was a wave recorder buoy anchored to the north of the platform with read-out in the forecasting office of the construction company, Howard Doris Ltd. A teleprinter link from Inverness Airport, a radio-facsimile receiver and best of all a telecopier completed the forecast office equipment. The forecasters were provided with extended forecast charts covering a period up to five days ahead. They also had copies of the unique surface wind output from the fine-mesh numerical forecast model run twice a day on the COSMOS computer system at Bracknell together with guidance forecasts issued by London Weather Centre to Chevron Petroleum. Formal briefings were given twice a day to the Chevron site manager and any of his staff who were involved in planning the next day's work.

The first submerging

For a few days after the transfer of the superstructure to the catamaran, the engineers were busy putting the final touches to the platform, removing the scaffolding from it and dismantling the cranes which had been used to build it. This gave the forecasters a few days to sort out their communication problems and to assess the problem of forecasting for a huge structure floating in a narrow bay between the mountains of Skye and the mountains of mainland Scotland.

In order to float the superstructure over the concrete base, the platform had to be ballasted deep into the water; at this stage the outer skin was being used for flotation and this was constructed with a honeycomb of holes, to act as a breakwater for the inner skin when the platform was in position. These holes had been plugged and it was decided to test the plugs by ballasting the structure down to the depth it would have to reach when the superstructure was floated over it. The task was fairly delicate since the collapse of one plug would probably mean the loss of the £30 million structure. At first a 15 knot weather window was required but as time went by and pressure increased the job was done in winds of nearly 25 knots and seas of 1 to 1·5 metres.

A weather window opens

On the morning of 21 November the forecast for late that week showed a col over the west of

Scotland, and the Chevron site manager called for a special briefing at 2200, after the issue of the extended forecast charts. These charts indicated a weather window on Friday the 26th, and the mobilization of manpower was started.

Count-down to the mating

During the next few days the platform was stripped of the remaining huts, cranes, aerials and of course the anemometer. Much of this work was carried out in atrocious weather. Thursday the 25th was a stormy day with violent showers and the crew aboard the concrete platform reported waves of 1·5 metres. At noon on Thursday the senior staff from Chevron's London Office were briefed. The weather forecast was good but the amount of swell forecast was not acceptable. A strong northerly wind had generated swell about 400 miles north of Kishorn, the wind in the generating area had moderated, and a swell of 30 cm with a period of 11 seconds was forecast for Friday morning, falling to nil by 1800 on Friday. At noon on Thursday the wave recorder was giving 80 to 100 cm waves with a maximum wave of 160 cm and a period of 5 seconds. There was no noticeable swell on the trace of the wave rider, but it was probably masked by the wind waves. During Thursday afternoon, reports available at the London Weather Centre indicated that the swell might have a shorter period, about 10 seconds, and observations by the light-keeper at Rudh Re 50 miles to the north of Kishorn indicated that the seas were moderating.

At 1800 on Thursday a meeting was held of all the senior engineers, marine superintendents, the senior tug skipper, and the representatives of the insurance companies covering the operation. The meteorological briefing came first, and very light winds and a rippled sea could be forecast with confidence but the exact figure of 30 cm of swell at dawn falling to nil by 1800 had to be qualified; however, since the calm was now certain to last until Saturday and the swell at worst would cause a delay, it was decided to start the operation at first light on Friday, provided that a weather check at 0500 proved satisfactory.

The first part of the job completed

At 0300 on Friday the wave rider buoy gave 20 cm, with a maximum wave of 25 cm and a period of 10 seconds; a hand anemometer on the concrete platform gave 15 knots. At 0500 the necessary insurance certificate was issued and by 0730 the tow out of Toscaig started. A report from the catamaran when clear of the harbour indicated a swell of 12 cm, and this agreed with the maximum wave given by the wave rider buoy. The wind fell to calm, no technical snags developed and the work was soon running ahead of schedule. By 1400 the final mating took place and at that time there was about 2·5 cm of vertical movement between the two structures; 'Just enough to jiggle the guide pins into place', said the engineer in charge. This implied a swell of about 6 cm.

Life on the North-west Frontier

Although three out of four of the forecasters involved in the work at Loch Kishorn were Scots, we were all city dwellers and found the north-west of Scotland in winter a strange but beautiful place. The snow fell and stayed white, the deer moved down from the hills and foraged each night between the cranes and the scrap iron for what bits of grass were left on the construction site. The early morning drive to work was always interesting, and sometimes impossible; then we would come in by boat, which was far more pleasant.

At first we were accommodated in a magnificent but unheated shooting lodge at Strathcarron. The walls were thick with the heads of ten-point stags but there was not a radiator in the place. The local

ladies who cleaned, and made the beds, were fresh-air fiends and always opened the windows wide; the night duty forecaster often returned to find inches of snow on the bedroom carpet. Later we moved into an hotel which was nearer to Loch Kishorn and was heated!

Fitting out the superstructure

After the critical mating operation there was a pause of a few days in the weather-sensitive activity at Loch Kishorn, but on 6 December a forecaster returned to the site to provide forecasts during the lifting of the prefabricated units containing workshops, generators and living accommodation. These lifts were up to 700 tons and were carried out by the derrick barge *Odin*.

The individual lifts only took a couple of hours, but between lifts the huge barge had to be manœuvred round the concrete tower to a new position and each move was a slow and delicate process; a snapped cable in a 25 knot wind could swing the barge on to the platform with shattering force. As the *Odin*'s charter time ran out it was necessary to use every minute of fair weather. The barge crew worked round the clock and the forecaster was needed from early in the morning until late at night. On 27 December the *Odin* sailed and the duty forecaster returned to the Weather Centre. In the New Year a further array of prefabricated modules was assembled at Loch Kishorn and a forecaster returned for a short period to help with their positioning. These lifts were generally much heavier, some of them over 1000 tons, but the derrick barge moved around the rig less often.

Getting ready for sea

Towards the end of April the platform was nearly ready to be towed into the North Sea. On the 24th a forecaster arrived at Loch Kishorn to find a hive of activity which made the earlier busy periods seem tame. The forecast office at the Chevron site was reopened and regular meteorological briefings were provided. The meteorological thresholds which were needed varied with the section of the route.

The tow could not be started in the confined waters of Raasay Inner Sound if the wind was force 5 or more, but in the open sea, winds of 40 knots and seas of 5 metres could be handled. However, over the relatively shallow water of Shiant Bank in the Minches the wind had to be less than force 5 and tides, currents, salinity and adverse weather all had to be considered before the tow started so that the platform would pass over the Bank with three metres' clearance from the sea bed.

The tow starts

On the morning of Wednesday 3 May the platform was ready to go but the forecast, which indicated a low moving across Ireland and Northern England, was not completely favourable and the tug skippers and insurers were reluctant to let the tow start, but later in the morning the next issue of 48 and 72 hour forecast charts suggested that the low would keep further south and at the afternoon briefing the decision to go was taken.

On Thursday 4 May the London Weather Centre forecaster moved aboard the tug *Smit London*. At 1800 on Friday the tow started and with apparent ease the 600 000 ton platform became the heaviest man-made object ever to move (see Figure 3). At 0500 on 8 May the platform crossed the Shiant Bank and the decision to shelter or move on had to be made. After receiving a favourable forecast from London Weather Centre the tow continued into the open sea.

A slight snag

During the afternoon the speed was increased to slightly over one knot and the platform developed

a marked list. The list was thought to be due to the drag effect of the base which was still close to the sea bed so the tow was slowed until deeper water was reached.

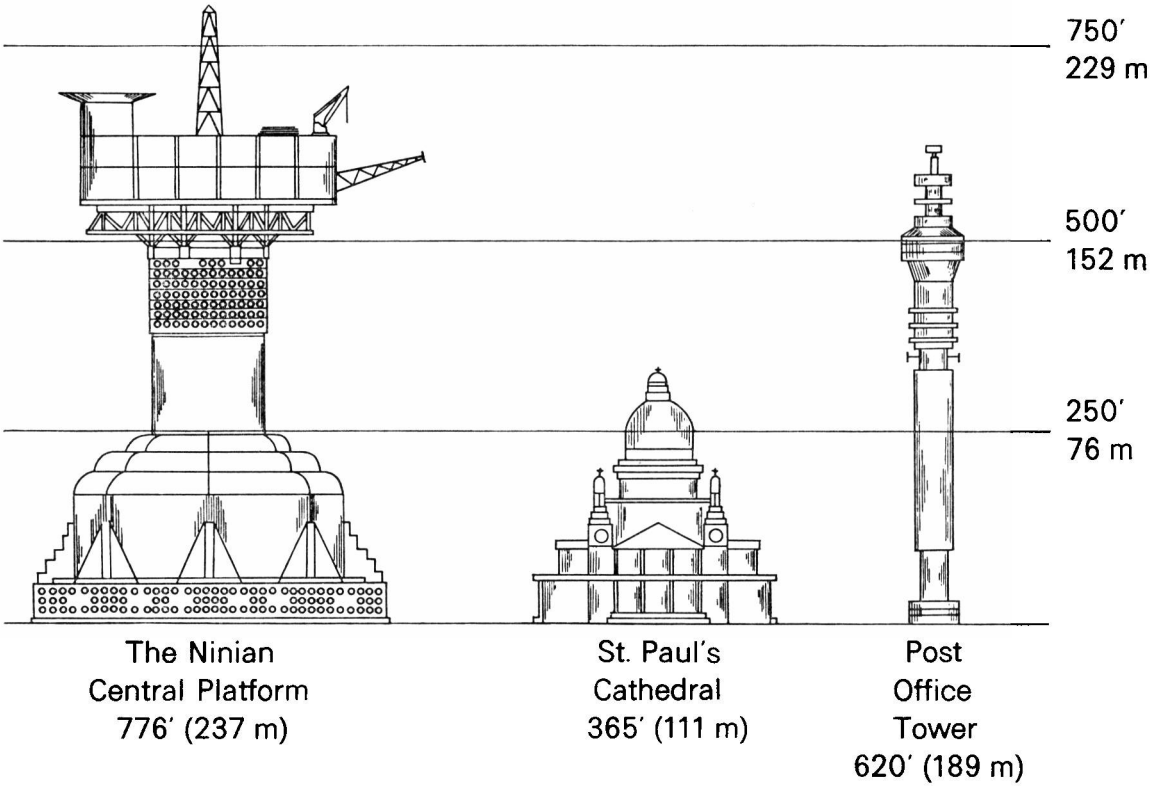

Figure 3. Pictorial comparison of the Ninian Field Central Platform and other well-known structures.

The job completed

From the 9th to the 15th the tow continued at nearly two knots until the shallower water near the Ninian Oilfield was reached. On the 16th, a forecast for the Ninian Field was issued, giving winds of 5 to 10 knots and significant waves of $\frac{1}{2}$ to 1 metre consisting mainly of a confused swell. After that forecast the tow moved straight to the Ninian Field.

On the 17th, a slow approach was made to the site, at 8 metres per minute, in almost perfect conditions with a smooth sea and a long, low westerly swell. The platform was slowly ballasted down and at 1800 it came to rest on the sea bed, perfectly aligned and only 10 metres off the chosen position.

Thick fog drifted over the Ninian Field that night and the forecaster had to decide whether to return to Shetland by helicopter or on one of the tugs. He chose the tug and received the supreme accolade as the Chevron staff all said, 'If the Met. man is going ashore by tug so are we'.

Appendix—The logistics of the operation

By R. M. Morris

(Principal Meteorological Officer, London Weather Centre)

The background leading up to the establishment of a forecasting office at Loch Kishorn is worth recording. Chevron had experienced a series of delays and occasional disasters during the previous winter and spring during the construction of the circular concrete platform at Kishorn, and the deck at Ardersier. The result was that the schedule fell too far behind time to allow for the critical mating with the deck to take place during the 'climatologically' favourable weather of summer. Chevron were thus faced with having to wait until the following summer before completing the mating. As a result of a preliminary contact by our offshore consultant in Aberdeen, Chevron approached London Weather Centre (LWC) about the possibility of carrying out the work during the winter by making maximum use of the expertise and skilful forecasting of weather windows by the offshore forecasters at LWC.

On Thursday 29 October 1977 Sam Murphy of Chevron flew down to London from Inverness to discuss the project with P.Met.O., LWC. By the early afternoon Murphy confirmed that Chevron would give LWC the contract for the forecast service. This service included the establishment of a local forecast office at Loch Kishorn with full back-up support from LWC. Just to show that we could move fast too, on the following Saturday P.Met.O. and a senior offshore forecaster (P. Deeks) flew up to Inverness to inspect the superstructure at Ardersier prior to its tow round to Kishorn. At the crack of dawn on the Sunday we flew by helicopter to Kishorn to see the site of the proposed forecast office and also inspect the floating concrete platform. The weather decided to put on a special show for us that day and the wind increased to 70 knots, straight up the Loch. We made a brave—one might almost say foolhardy—attempt to visit the platform (6 miles away, in deep wet dock) by tug but we were forced to return to base as the vessel could make no headway into the storm. Later we flew back to Inverness by helicopter (a truly remarkable experience in those conditions). I think the fact that we undertook the boat and the helicopter trips impressed Chevron more than anything else that day. By Monday lunchtime (2 November) we were back in London and the organization was set in motion.

A forecaster was detached from LWC to Kishorn within 72 hours. A radio-facsimile receiver and recorder were taken from the radiosonde station at Leuchars to Kishorn, and a document facsimile from Interscandex in Inverness quickly followed to establish a direct documentation link between LWC and the site. There was already a telex line available but the most impressive action was the establishment of a land-line by the Post Office within 14 days to enable the meteorological teleprinter broadcast from Bracknell to be received at the site office. In all there were four forecasters deployed on the site, three from LWC (Messrs M. McColm, O. M. Hull and J. G. Allardice) and J. R. Hill from Glasgow Weather Centre. At any one time there were two forecasters at Kishorn covering the 24 hours and each tour of duty lasted about two weeks.

There is no doubt that the whole operation was a major success and an excellent tribute to the co-operation between all the sections of the Meteorological Office that were involved, i.e. Supply and Finance (Met O 4), Telecommunications (Met O 5), Public Services (Met O 7), the Central Forecasting Office, and the London Weather Centre.

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The clearance of persistent fog

By A. A. Brown

(Meteorological Office, Birmingham Airport)

Summary

An investigation was made into the behaviour of fogs which had already persisted from 09 to 17 GMT. It had been noticed that such fogs often seemed to clear during the following night. This is confirmed by the results of the investigation.

Introduction

In radiation conditions the usual expectation is for fog to form rather than disperse at night. However, some fogs do disperse during night-time, and the purpose of this investigation was to examine the behaviour during the subsequent night of fogs which had persisted throughout the day.

It should be emphasized at this stage that no attempt has been made to explain why a fog persists all day, nor yet to find specific reasons for individual fog clearances. Rather the point of the exercise is to highlight the facts that

(a) persistent day-long fogs are perhaps more common than is generally realized, and that

(b) clearances at night are also quite common.

Records for 20 inland stations* in England (shown in Figure 1) were examined from 1975 back to 1967. Earlier than this, it was felt that smoke pollution prior to implementation of the Clean Air Act would distort the results. The choice of stations was restricted to those whose data were available on the computer 'climat' tapes. Where data were missing from the tapes, they were obtained directly from the observation registers of the stations concerned. Hill stations (more than 150 metres above mean sea level) and coastal stations were excluded. Liverpool, however, was included as an inland station because in radiation conditions the wind drift over Liverpool is invariably from the south-east owing to the terrain, and the effect of the adjacent Mersey is largely negated. This was supported by the Meteorological Office staff at Liverpool Airport. The data obtained during this investigation confirmed this point and there was reasonably good agreement between the figures for Liverpool and those from some of the other inland stations.

Only the four winter months from November to February were examined because a pilot survey showed that the occurrence of persistent fog (excluding sea fog) is rare in other months.

The figure of 600 metres was taken as the upper limit in this investigation. This is the halfway point between the upper limits of 'public' fog at 200 m and 'aviation' fog at 1000 m. Also a visibility of 600 m on Runway Visual Range is the limit above which many civil aviation operators can legally make an approach to an airfield.

In general terms it can be argued that a 'normal' fog is one which forms during the night or around dawn and then clears during the following morning, often in the period between 10 and 12 GMT in these winter months. For this investigation a 'normal' fog is so defined. The incidence of fog (using the same 600 m criterion) for each station at 09 GMT gives an indication of the complete winter fog picture, that is to say, 'normal' plus 'persistent' (defined below) fogs. By relating this incidence to that of the 'persistent' fog, a reasonable comparison can be obtained between these two types of fog.

* Following closure of two of the stations, Mildenhall in 1969 and Abingdon in 1974, the series was continued using Honington and Benson respectively.

Figure 1. The 20 stations concerned in this investigation.

Extraction of data

Table I column (b) shows the number of days in the four winter months November–February over the eight and a half winters in the period from November 1967 to December 1975 when the visibility remained below 600 m from 09 to 17 GMT with no more than a one-hour 'break' of visibility above this limit. Such days were defined as 'persistent' fog days.

Two hundred and sixty-one such days (events) were identified and these occurred on 90 actual dates. Visibility is recognized as being a most variable meteorological element in time and space for any given synoptic situation. In other words, visibility changes at one station are not necessarily connected with those at another station under the influence of the same synoptic system. As there was often a wide disparity of fog-clearance times for these 90 dates, it was decided to treat each event separately.

Table I. *Number of days with fog in the four winter months November–February over 8½ winters from November 1967 to December 1975*

	(a) Height of station in metres above mean sea level	(b) Number of persistent fog days	(c) Number of days with fog at 09 GMT	(d) = (c) − (b) giving number of normal fog days
Wattisham*	87	18	102	84
Stansted*	106	18	113	95
Mildenhall*/Honington*	9/53	14	70	56
Marham*	24	16	96	80
Waddington*	70	21	99	78
Wittering*	84	26	97	71
Watnall*	107	23	118	95
Coltishall*	19	9	71	62
Finningley*	17	13	77	64
Leeming*	40	21	94	73
Manchester	78	17	51	34
Shawbury	76	8	53	45
Birmingham	99	9	65	56
Pershore	40	9	81	72
Boscombe Down	124	9	73	64
Gloucester	27	5	43	38
Abingdon/Benson	82/70	8	70	62
Heathrow	24	5	42	37
Gatwick	62	5	58	53
Liverpool	26	7	61	54

For the 20 stations the average number of persistent fog days per station per winter was 1·5. The stations marked with an asterisk can be broadly regarded as being situated in East Anglia together with Yorkshire. For the 10 stations in this eastern area the average per station per winter was 2·1 and for the other 10 stations it was 1·0.

Table I, column (c) shows the number of occasions when the visibility was 600 m or less at 09 GMT for the same stations in this period from November 1967 to December 1975. The figures shown are in good agreement with the generally accepted characteristics of the stations concerned.

Subtracting the number of persistent fog days from the number of occasions at 09 GMT gives the number of 'normal' fogs in this period (Table I, column (d)).

For the 20 stations the average number of normal fog days per station per winter was 7·5. For the 10 stations in the eastern area the average was 8·9 and for the other 10 stations it was 6·1.

It is interesting that for persistent fogs the 10 eastern area stations have 2·1/1·0 = 2·1 times the average for the other 10 stations, and for normal fogs the 10 eastern area stations have 8·9/6·1 = 1·5 times the average for the other 10 stations. These ratios, especially the higher one for the persistent fogs, are a good indication of the influence of the North Sea in providing a supply of moist cool air both on producing and also maintaining fog at this time of year.

In order to demonstrate that persistent fogs are not rare events, consideration of the ratio of persistent fog to normal fog for all 20 stations, when expressed as a percentage, shows that 16 per cent of all fogs reported at 09 GMT persist until 17 GMT in these winter months.

Analysis of the occasions of persistent fog

The occasions were tabulated month by month thus:

November	December	January	February	Total
49	87	88	37	261

It was found that any number of stations could be affected at any one time. This distribution is not unexpected in view of the radiation balance for this time of year. It is clear that the stronger higher-level flows are not reflected at the surface with more wind and less fog.

The numbers of days in each month on which a persistent fog occurred (regardless of the number of stations affected) in the eight and a half winters were also tabulated thus:

November	December	January	February	Total
15	31	31	13	90

Again this distribution shows no abnormal pattern and is consistent with the previous table.

The height in metres of each station above mean sea level is shown in Table I, column (c) and a comparison of column (a) with column (b) does not reveal any simple association between these heights and the incidence of persistent fogs.

Clearance of persistent fog

The 261 persistent fog events in this period having been identified, the time of clearance of the fog was noted. A clearance was defined as the time at which the visibility improved to more than 600 m and remained so subsequently for at least three hours. Three hours was thought to be the minimum period which could be operationally useful, for example, for recovering a squadron of military aircraft or permitting the movement of a significant number of passengers from a civil airport. When a clearance as defined above did not take place throughout the next 18 hours following persistent fog, it was defined as a NIL clearance.

Figure 2 shows a graph of the number of occasions each hour when persistent fog clears, plotted against the clearance times. From the graph it can be seen that there are marked peaks at 19, 00, 03, 06 and 10 GMT. It was found from statistical tests—see Appendix—that these peaks, as a departure from the mean curve, could occur by chance except for the one at 10 GMT. This latter is almost certainly due to the normal diurnal clearing agents finally working to clear the fog on day 2.

The peaks at 19 and 06 GMT, approximately dusk and dawn in the period under investigation, fall within the limits of chance, but, as discussed in the Appendix, there is some statistical evidence to suggest that the large number of clearances at 06 GMT is a real phenomenon.

Where a clearance occurred around these times (18–20 and 05–07 GMT), the observations were checked to see if the clearance had been caused by a small change, possibly due to the change in lighting conditions from day to night and vice versa, but it was found that in all cases the changes were real ones, often by a factor of more than 50 per cent. The corresponding transmissometer records for the events at Birmingham Airport were analysed and they confirmed this point.

Figure 3(a) shows the cumulative percentages of clearances by a given hour for the two areas—east and west. It is interesting to note that in the western area half the clearances occur within seven hours of the end of the persistent fog day (17 GMT), that is to say before midnight GMT, whereas in the east the halfway point is not reached until after 02 GMT. This probably reflects the fact that, in general, synoptic effects progress from west to east.

By 08 GMT, 87 per cent and 70 per cent of the persistent fogs have cleared from the western and eastern areas respectively so that the odds are greater than 6 to 1 and 2 to 1 respectively that a persistent fog will clear before dawn.

Of the 261 total events, 31 occasions (approximately 12 per cent) were NIL clearances as defined previously, and 28 of these were in the eastern area. The only stations in the western area to record a single NIL clearance apiece were Abingdon, Liverpool and Pershore. Of these 31 events, about half

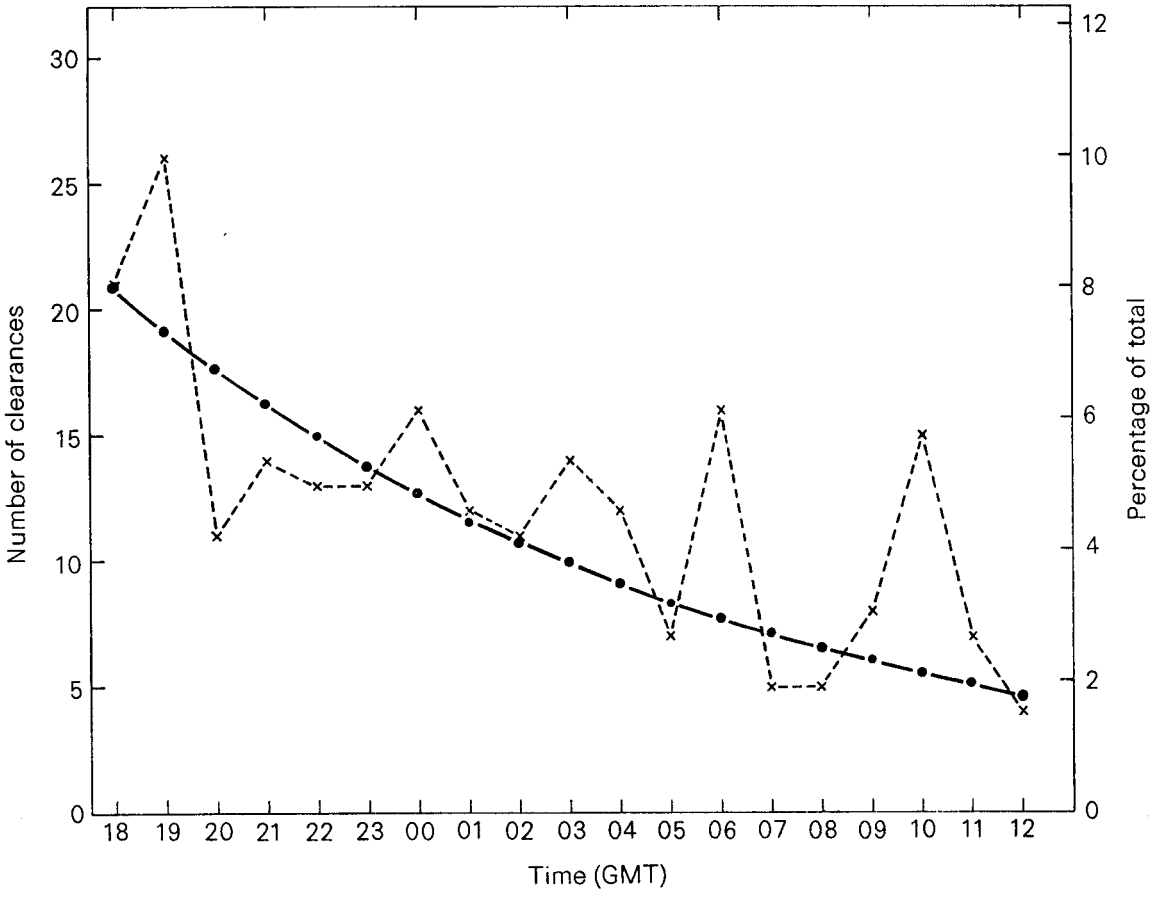

Figure 2. Numbers of clearances each hour plotted against clearance times (x - - - x) and hypothetical 8 per cent clearance rate (· —— ·). Total number of clearances = 261. Number of NIL clearances = 31.

(15) led to a second persistent fog day with the clearance occurring late on day 2 or during day 3. In this period under investigation, fog did not persist at any of these stations for more than three days, in contrast to the six-day fog over south-east England in November 1962.

Reasons for clearance of the persistent fogs

Although the scope of this investigation was not intended to cover the reasons for clearance of persistent fogs, it was felt that a brief examination of the causes might be useful. A subjective analysis of these occasions was therefore made, mainly using the relevant *Daily Weather Reports*. These clearances were categorized in terms of well-known causes as follows:

(a) Frontal: an organized frontal system was present, usually within 200 km.

(b) Wind: mostly a straightforward increase in wind strength; on occasions it was possible to identify

from the station's observations that the clearance was due to the advection of drier air. Sometimes, from a personal knowledge of the local geography, the clearance could be identified as due to a change in wind direction.

(c) Cloud: including all types of cloud, but with no frontal system in evidence.

(d) Miscellaneous or unknown reasons: this group was necessary because the dividing line between (a), (b) and (c) was in some cases marginal. This emphasizes the subjective nature of the analysis and the difficulty of using DWRs for such micrometeorological events. It was not possible to examine these occasions in greater detail.

However, these 261 events break down as shown in Table II.

Table II. *Number of clearances by type*

(a) Frontal	(b) Wind	(c) Cloud	(d) Miscellaneous	NIL clearances	Total
81	90	48	11	31	261
		Expressed as a percentage for each category			
31%	35%	18%	4%	12%	100%

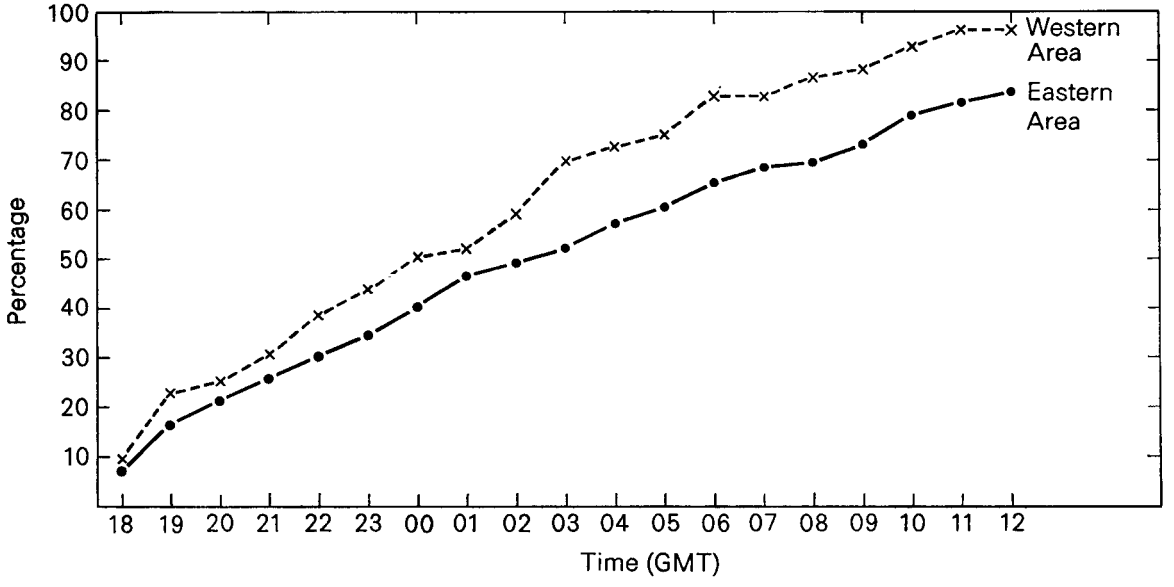

Figure 3(a). Cumulative percentages of persistent fogs that clear by given hour. Western area (84 events) x - - - x; Eastern area (177 events) · —— ·.

Figure 3(b) shows a graph of cumulative percentages of clearances with the cause of clearance shown.

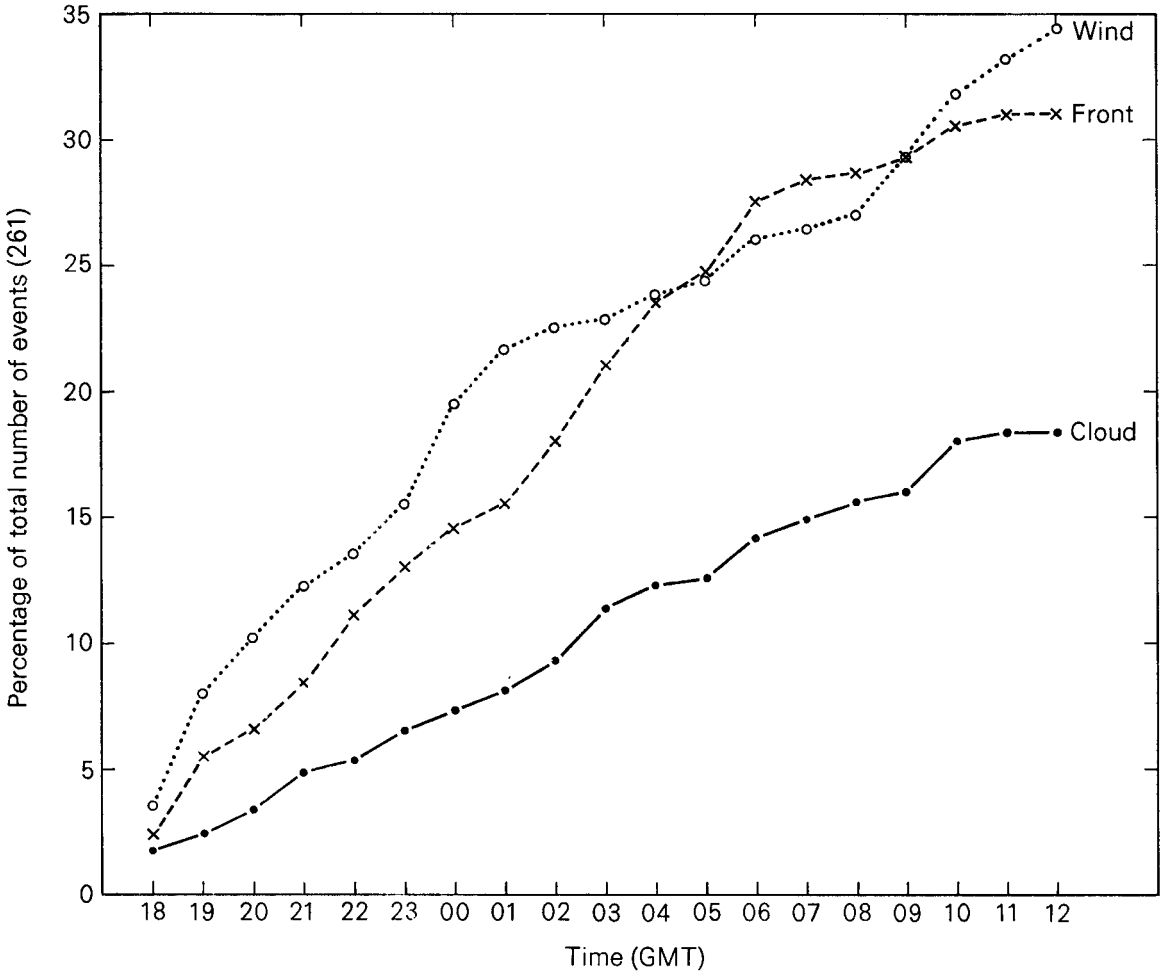

Figure 3(b). Cumulative percentages of persistent fogs clearing in each hour with cause of clearance.

Verification of the frequency of persistent fog days

The period January 1976 to February 1977 was used to verify the frequency of persistent fog events. The average number of persistent fog events was 1·7. For the eastern area it was 2·3 and for the other 10 stations it was 1·1. These figures are in close accord with those obtained previously.

Conclusions

A persistent fog was defined as one which lasted from 09 to 17 GMT; it is not a rare phenomenon. Records for 20 inland stations in England show that 10 of the stations, which are situated in an area roughly to the east of the M1 motorway, had on average two occurrences per winter and the remaining 10 stations averaged one occurrence per winter. It was rare for there to be more than four such occurrences per winter at a station.

Some 18 per cent of clearances of all persistent fogs occurred by 19 GMT and 44 per cent by midnight GMT. It is suggested that this latter percentage could be represented in a TAF, say by TEMPO 0104 or PROB 30 for example*, with an even chance of getting it right; in the case of public service forecasting, one could suggest the fog becoming patchy as opposed to remaining widespread.

On 12 per cent of occasions the fog persisted for at least a further 18 hours from 17 GMT and on nearly 6 per cent of occasions the fog persisted until at least 17 GMT on the second consecutive day.

On 35 per cent of occasions the clearance appeared to be associated with a change in the wind, on 31 per cent with a front and on 18 per cent with a change in the cloud cover. On the remaining 4 per cent of occasions the reason for the clearance was not easy to define. It appears that with any sort of front approaching the area or with any marked change of either wind speed or direction indicated, clearance of a persistent fog during the evening or early night could fairly confidently be forecast.

In other words, although at the time, say between 17 and 23 GMT, there may be virtually no indication on the hourly charts of any major change taking place, this is the time to look for some hint of even a small change, for example the appearance at certain stations of slightly bigger pressure tendencies than one would expect in such a flat situation. At a particular station, perhaps it will be a change in the direction of the wind drift that is the clue. A diligent search by the duty forecaster may turn up enough evidence to suggest a particular occasion as likely to be one of those where, on the basis of long-term statistics, a clearance is to be expected: the TAF can then be refined accordingly.

On a day of persistent fog, the duty forecaster at any station is always under a lot of pressure, due not least to the sheer volume of enquiries. Towards the end of such duties and once the psychologically important time of 16 GMT (the sun is going down, temperatures are falling etc.) has passed, the author recalls that on occasions he had assumed, almost without thought, that in the apparent absence of any marked clearance agents the fog would persist overnight. In the light of subsequent personal experience and also from the results of this investigation, it would seem that such an assumption is not necessarily likely to be true.

Acknowledgements

The author would like to thank the many colleagues who helped to extract data from the observation registers and also Mr C. L. Hawson of the Special Investigations Branch of the Meteorological Office for his assistance in the preparation of the final draft.

* These technical terms of aviation forecasting are defined in *Handbook of Weather Messages, Part III.*

Appendix

From Figure 2 it can be seen that there are marked peaks in the number of clearances of persistent fog at 19, 06 and 10 GMT and a marked trough at 20 GMT. To determine the significance of these peaks and troughs a null hypothesis was assumed and a chi-square (χ^2) test applied to the whole series.

The null hypothesis. Assume initially that there is no preferred hour for the dispersion of a persistent fog, the time of arrival of the clearing agent being random. Under these circumstances it is reasonable to expect that the clearances in any one hour will be proportional to the number of outstanding events and give an exponential type of distribution for the clearances. As a corollary to this hypothesis, since the onset of diurnal clearing factors is not random then a significant departure from this assumed hypothetical clearance rate can be expected some time after dawn. This is consistent with general meteorological experience of non-persistent fogs which tend to clear preferentially about mid-morning.

Now, 261 events exist at 17 GMT and 21 of these (i.e. 8%) clear by 18 GMT. Applying the null hypothesis, 8% of the outstanding (92%) events will clear in the next hour. Thus 7·4% of the total clear in the hour ending 19 GMT, and 6·8% of the total clear between 19 and 20 GMT. Continuing this calculation throughout the night provides the results which are plotted on Figure 2 to make up the curve labelled '8% reduction rate'.

Table A1 shows the χ^2 totals derived from the difference between the observed fog clearances after 17 GMT and expected clearances at a reduction rate of 8% of the outstanding events.

Table A1. *Chi-square test for observed fog clearances after* 17 *GMT and expected clearances at a reduction rate of* 8 *per cent*

Hour (GMT)	Observed clearances	Expected clearances	Cumulative total chi-square
18	21	21	0·00
19	26	19·5	1·85
20	11	18	4·20
21	14	16·5	4·44
22	13	15	4·59
23	13	14	4·61
00	16	13	5·09
01	12	11·5	5·09
02	11	11	5·09
03	14	10	6·32
04	12	9	7·01
05	7	8·5	7·13
06	16	7·5	15·66
07	5	7	15·98
08	5	6·5	16·13
09	8	6	16·51
10	15	5·5	31·24
11	7	5 }	31·35
12	4	4·5 }	
13 or later	31	52	39·43
10 or later	57	67	17·86

Note. Yates's correction has been made to the value of O–E (Observed minus Expected) for continuity because the data relate to a discontinuous variable.

Consider the values of χ^2 calculated from the departures from expectation of the numbers of clearances when these are taken hourly up to 09 GMT but are combined into one class for 10 GMT or later.

$\chi^2 = 17·9$ for 16 degrees of freedom. There is approximately a 35 per cent chance of getting values as big as or bigger than this by accident. The conclusion is that the data are consistent with the null hypothesis holding up to 09 GMT.

Now consider χ^2 when the clearances are taken hourly up to 12 GMT and combined for 13 GMT or later.

$\chi^2 = 39·5$ for 18 degrees of freedom. There is a less than 0·5 per cent chance of getting values of this order by accident, and the conclusion is that the working hypothesis does not hold to 12 GMT. It can be seen from the detail of the calculation that it is the excessive number of clearances between 09 and 10 GMT which causes the conflict with the hypothesis. This is as expected from the corollary to the hypothesis as stated previously.

To test the individual hourly totals, a 'Student's' *t*-test was applied, using the calculations set out in Table A2.

Table A2. *'Student's' t-test based on percentage differences of observed and expected fog clearances in each hour for the sample of* 261 *events* (*Figure* 2)

Hour (GMT)	x (Observed − Expected) *per cent*	t value	Equivalent probability for single-sided test
18	0	0	
19	2·55	1·63	6%
20	−2·6	−1·67	6%
21	−0·9	−0·58	
22	−0·8	−0·51	
23	−0·3	−0·19	
00	1·2	0·77	
01	0·1	0·06	
02	0	0	
03	1·5	0·96	
04	1·0	0·64	
05	0·6	0·38	
06	3·0	1·92	4%
07	−0·8	−0·51	
08	−0·6	−0·38	
09	0·7	0·45	
10	3·6	2·31	2%
11	0·7	0·45	
12	−0·3	−0·19	

Parameters of this distribution: $\bar{x} = 0{\cdot}392$; standard deviation = 1·509; root-mean-square = 1·559; $t = x$/r.m.s.

If, for reasons unconnected with these data, the departure is expected to be positive and a maximum at 10 GMT, then testing 1000 as though it were a single one-sided trial, there is only a 2% chance of getting a positive t as large as or larger than this by accident in a random sample. The conclusion is that the 10 GMT results are incompatible with the null hypothesis but in line with the corollary. Similarly, the equivalent probabilities for 06 and 19 GMT are 4% and 6% respectively. These values, on the basis of the null working hypothesis, are on the borderline of the generally accepted significance level of those expected by chance in a random sample of 19 values.

It is possible that an observer is more able to assess actual visibility at 06 GMT—given the advantage of a little actual light—than would be possible earlier when in view of the persistence of the fog there could be a tendency to underestimate visibility. Similarly at 19 GMT when it is fully dark, the transition from natural lighting may be having an effect. The fact that clearances in the next hour (20 GMT) are apparently excessively low relative to the null hypothesis conforms to what might happen if the peak at 19 GMT is a lighting effect. This peak at 19 GMT shows up primarily at the western stations. The fact that there are no excessively low frequencies of clearances leading up to 06 GMT or immediately afterwards tends to support the suggestion that this 0600 peak is a real phenomenon. There are no sound physical reasons why this should be so, but it is worthy of note that nearly 6% of the total clearances occur at this time (06 GMT), i.e. about twice as many as would be inferred from the general run of the graph.

To sum up:

(1) Observed departures from the expected hypothetical 8% reduction curve of fog clearance could readily occur by chance up to 09 GMT.

(2) Clearances between 09 and 10 GMT are significantly more frequent than such a curve indicates—consistent with increasing diurnal factors.

(3) The peak in clearances around 'first light' and 'first darkness' may be artifically induced, may be accidents of the sample, but could be real phenomena.

551.58:001

The distinction between weather and climate

By B. J. Mason, C.B., F.R.S.

(Director-General, Meteorological Office)

Summary

It is necessary to distinguish clearly between weather and climate, and definitions suitable for this purpose are proposed. The definitions are useful for the rational discussion of the concepts of climatic variability and climatic change. These definitions were adopted by the recent World Climate Conference.

Present interest in climate and climatic change would appear to require definitions of both weather and climate leading to a clear distinction between the two concepts. Such definitions, if they are to be useful and gain acceptance, should conform as far as possible to common understanding and practice and not depend on the results from a particular model or on a theoretical criterion which cannot be tested by observations. It is in this spirit that the following definitions are proposed.

Weather is associated with the complete state of the atmosphere at a particular instant of time and with the evolution of this state through the generation, growth and decay of individual atmospheric disturbances.

Climate is the synthesis of weather over a period long enough to *establish* its statistical properties (mean values, variances, probabilities of extreme events etc.) and is largely independent of any instantaneous (weather) state.

Because weather systems range in scale from small shower clouds to the planetary waves, with life-times ranging from less than one hour to several weeks, this concept of weather embraces all these time scales but with no sharply defined upper limit. Rapid atmospheric fluctuations with periods of up to a few days, originating largely within the atmosphere itself, are naturally ascribed to weather, and it is sensible to extend the concept to cover stable, large-scale features of the atmospheric circulation, such as blocking situations, that may persist and dominate the weather for several weeks. Alternatively it may be more useful, especially in retrospect and when the daily sequence of events is not of great interest, to characterize the atmospheric state over a month or season by a statistical description in terms of averages, standard deviations and frequency distributions of daily values. Such a statistical summary of the weather of, say, a particular January could not sensibly be described as the *climate* of that particular month although we can speak of a January climate based on the statistics of a long series of Januarys. Furthermore the statistical description of a particular January may be described in terms of its departure from the 'average' or 'climatological' January or the January climate.

For example, in the following statement: 'The mean daily temperature at Kew during February 1947 was −1·1 °C with a standard deviation of 1·76 °C. This was the lowest such February temperature since 1895, being 6·0 °C lower than the corresponding average for the 30-year period 1906–35', the first sentence is a statistical description of one weather parameter, temperature, for the month of February 1947, whereas the second sentence sets this in its climatological context.

As the period of the sample is extended from months to seasons to years . . ., synoptic descriptions in terms of day-by-day fluctuations become less and less useful and are replaced by statistical descriptions so that the concept of weather is eventually displaced by that of climate. However, the interannual variations are usually such that, say, a January or a spring climate can be established only if the record spans a sufficiently long sequence of Januarys or springs for the statistics to be treated

as if they were stationary. Since this usually requires a record of at least 30 years' duration, it seems inappropriate to apply the term climate in any of the above contexts unless the statistics cover at least a decade. The fact that the statistics of many global circulation and so-called climate models achieve a steady state more rapidly than the real atmosphere is to be regarded as a deficiency of the models rather than a good reason to change the definition of climate.

There have been attempts to draw a sharp distinction between weather and climate, for example, by defining weather in terms of the longest period over which an initial state continues to exert a detectable influence on future developments and for which it is possible to make deterministic predictions. At present, such a definition would set the upper time limit for weather at about one week. This seems an unrealistic and unnecessarily restrictive definition imposed by the limitations of current prediction models and, even so, cannot set a well-defined time limit because the periods over which developments can be followed or predicted depend on the initial state. Nor does it seem possible to separate the two concepts according to mechanism or to the components of the geophysical system involved. Although short-range weather forecasts are concerned largely with atmospheric fluctuations while climate involves also the more slowly changing oceans, land surface and ice sheets, for periods beyond 1–2 weeks it is not possible to ignore the cumulative effects on the atmosphere of changes in ocean surface temperatures, or of widespread even if temporary changes in snow-cover, vegetation, soil moisture, etc., some of which may be induced by the atmospheric fluctuations themselves.

In general, however, we are not so much concerned with the definition of climate *per se* as with *climatic variability* and *climatic change*. These terms imply departures from a normal regime, the definition of which must be to some extent arbitrary and based on the statistics of a limited past record. We could, for example, specify limits within which mean values, variances or the frequency of values within stated ranges may be regarded as 'normal'. Events outside these limits would then be regarded as anomalous at a certain level of significance and if the statistical properties of a succession of years, decades, centuries, etc. differed consistently and significantly from those of the 'normal' population, we could speak of a *climate change* on the appropriate time scale. Small, gradual changes may not be detected above the normal variability (noise) until long after they have commenced but larger changes will show up sooner. 'No change' would imply that all the observed fluctuations lie within expectation based on the statistics of the long-term record.

The term *climatic variability* may be used to denote variability *within* climate, i.e. fluctuations in the statistical properties over periods of weeks, months or years to cover such events as persistent blocking situations, Sahelian droughts and interannual variations. If a particular month, season or year were to show marked differences from the corresponding long-term (e.g. 30-year) average then it could be regarded as a *variation or an anomaly within* the climate of that period.

Given that there is no natural or precise time scale distinguishing weather from climate, the difference becomes largely one of viewpoint, method and utility. Weather is concerned with the evolution of a succession of atmospheric states or individual disturbances; climate with the long-term average behaviour of the atmosphere expressed in statistical terms. Weather forecasts are usually presented as being deterministic in nature; predictions of climatic variability (in the sense defined above) will, for the foreseeable future, be probabilistic statements based largely on the statistics of past records. In an operational context, weather is largely of tactical significance whereas climate is a strategic concept of value in forward planning, risk-assessment and decision-making.

551.5:06(b):061.4

Meteorological Office participation in exhibitions

By R. D. Hunt

(Meteorological Office, Bracknell)

Summary

The market for highly specialized weather information is potentially lucrative and for many years the Meteorological Office has been attempting to increase the revenue earned from the sale of tailor-made services. This can only be carried out successfully if the approach is wholehearted, and one of the fields which it has been necessary to enter is that of publicity. In particular, appearances at exhibitions have become an important means of displaying our services. Both from a commercial and a public relations point of view they have been found to be of great value.

Introduction

Traditionally the major role of the Meteorological Office was to provide essentially free services to meet the needs of Defence, the Merchant Navy and the general public; as far as was possible free services were also extended to any person or organization who asked for meteorological advice. However, in the 1950s it became clear that there were many highly weather-sensitive activities which required specialized services and that these services had a commercial value. Many public and other organizations either required forecasts of a far more detailed nature than could be obtained through the news media or needed detailed climatological information that was expensive to produce. In the late 1960s, the explosive growth of the offshore industry led to a rapid development in specialized meteorological services, particularly at London Weather Centre. Quite apart from the obvious safety aspects, operating companies found that meteorological services could make a substantial and cost-effective contribution to their work. With such a potentially large market for meteorological advice, not surprisingly several private firms of meteorological consultants entered the field, and for the first time the Office found itself with commercial rivals and the need to sell its services in the market-place.

The importance of publicity and exhibitions in particular became apparent in 1975. At the highly influential Offshore International '75 Exhibition in Aberdeen, stands were mounted by some of our commercial competitors and even by other government departments but a Meteorological Office stand was conspicuous by its absence. If a more commercial approach was to be successful it seemed vital for the Office to display its services at trade exhibitions where useful contacts could be made. At the next Aberdeen exhibition in 1977 therefore, the Meteorological Office was represented by a stand produced within the Office, largely by the Cartographic Section. This was successful in many ways although with the limited resources available the stand was not as impressive as many of the others. However, contacts were made at the time with the MOD Directorate of Promotions and Facilities (MOD (DPF)) who are able to sponsor activities in the field of publicity and who have since been of great assistance to the Office; with the aid also of the Central Office of Information (COI) we now have access to professional exhibition design services and during 1978 these were used at three important exhibitions.

Apart from the commercial advantages of appearing at exhibitions there is also a very important public relations aspect. Indeed at some of the more popular events (such as boat shows) having an opportunity to explain the work of the Office to large numbers of the general public is both useful and rewarding. With this in mind, displays have been mounted at a number of locations close to Weather Centres, for example at Manchester and Middlesbrough. For these the Cartographic Section produced some fine displays and the results were highly successful in bringing the work of the Weather Centres to the attention of the public.

Exhibitions sponsored by MOD (DPF) during 1978

The largest and probably most impressive stand during the year was at the Oceanology International Exhibition in Brighton during March. Several branches of the Office were actively involved in the preparation of the exhibits for the stand. A working forecast office was set up equipped with a teleprinter and facsimile machines to receive a wide range of current meteorological data. Forecasters from London and Southampton Weather Centres were able to prepare up-to-date forecasts and to discuss with visitors the various aspects of forecast production. The very good satellite pictures received on the stand were of particular interest to visitors, and the relation between these and the current analyses was explained. The pictures, together with forecast charts for 24, 48 and 72 hours ahead, were attractively displayed on a board illuminated from behind and with a coloured underlay making it easy to distinguish geographical features. Staff from the Weather Centres were able to talk in detail about the specialized services for the offshore industry which were offered mainly from London but also from other forecast offices including the newly formed public service cells at Lerwick, Kirkwall and Aberdeen. A telecopier machine was also installed to demonstrate how charts and other material could be passed between these outstations and directly to customers.

Although current forecast information is vital for day-to-day offshore operations, climatological data are of great importance to operators, engineers and designers; the Marine Climatology section of the Climatological Services Branch therefore featured prominently in the display. By means of a special terminal on the stand, direct access was obtained to a marine data bank held on-line in the COSMOS computer at Bracknell; it was thus possible to demonstrate the wide range of processed and unprocessed data that are readily available and the speed with which they can be obtained. A great deal of work had been necessary before the Exhibition to prepare the data bank and the access programs, but the demonstrations using the terminal were very successful and the output was impressive.

A wide variety of instruments suitable for a marine environment was demonstrated by the Operational Instrumentation Branch whose contribution included a working automatic weather station with provision for 'call up' so that current data could be displayed. This and other instruments including humidity sensors and anemometers attracted an encouraging number of enquiries which were dealt with by staff from this Branch. The final contribution was from the Marine Division; this consisted of a plinth displaying a marine screen and precision aneroid barometer with a static pressure head as well as a display detailing the ship routeing service, a model of an observing ship and the ship's log book. As well as staff from the ship routeing service, specialist staff who advise on siting of instruments on rigs and platforms and on the making of weather observations, were also available to discuss these services.

All the contributions mentioned above were accompanied by professionally designed and produced boards containing scripts and diagrams prepared by the respective branches in conjunction with the Public Services Branch, and brochures illustrating the services offered by the Meteorological Office were available on the stand. The Telecommunications Branch also made a key contribution by arranging for the Post Office to install the many lines without which neither the computer terminal nor the forecast office could have operated. The net result of all this work was a stand which impressed participants and visitors to the exhibition alike.

The second MOD (DPF) sponsored exhibition during the year was the Southampton Boat Show in September. The stand here was modest by comparison with that at Brighton and was rather a long way from the main show area. The emphasis of the display was on the services which are available to yachtsmen and owners of small boats and the facilities that can be provided for them by Southampton

Weather Centre. At the front of the stand, the up-to-date charts were displayed in much the same way as at Brighton, facsimile machines having been installed to enable current material including satellite pictures to be received. These proved to be a most successful way of attracting people to the stand and the staff from London and Southampton Weather Centres who manned the exhibit spent a lot of their time explaining the charts and leading those interested to the other parts of the display.

The rest of the stand showed how observations were received from all parts of the world; satellite pictures were displayed together with enlarged photographs of various sources of data including radiosondes, ocean weather ships and lighthouses. Some attempt was also made to described diagrammatically the operation of the global telecommunications network.

Many yachtsmen's plotting charts were sold during the exhibition, and although the amount of business accruing from the Show was probably somewhat limited, this display was intended primarily as a public relations exercise, attracted large numbers of visitors and undoubtedly achieved its object. The importance of this aspect of exhibitions and indeed of other forms of publicity should not be underestimated.

The other main exhibition of the year was the European Offshore Petroleum Exhibition and Conference (EUROPEC) at Earls Court in October. The Meteorological Office contribution here was very much along the lines of that at Brighton although owing to the smaller amount of space allocated to the Office at Earls Court certain features prominent at Brighton had to be left out. These included the terminal to the marine data bank and the satellite facsimile machine. Although the number of visitors to the exhibition was relatively small, those who were present were actively involved in the offshore industry. This led to many useful contacts being made with staff from all the branches represented.

Other 1978 exhibitions

Apart from these exhibitions, display boards produced within the Meteorological Office, mainly in the Cartographic Section, also appeared at various other shows. These included the Royal Agricultural Show at Stoneleigh (where a video-cassette made by the BBC showing how the TV Farming Forecast is produced was shown), a 'Climate and Weather' exhibition on the Isle of Wight, and the special exhibition arranged by the Royal Meteorological Society to mark the visit to Bracknell of HM The Queen. On a different theme and with the valued assistance of the High Atmosphere Branch, a contribution was also made to a 'Physics at Work' exhibition organized for schoolchildren by the Institute of Physics and shown at the University of Surrey.

Conclusions

There is little doubt that displaying Meteorological Office services at specialized exhibitions can lead to important contacts being made and subsequently to new requests for our commercial services. Although it is impossible to state precisely what the financial benefits are—no contracts are actually signed on the stand—it is clear that all the branches represented at Brighton gained new business. For London Weather Centre services at least, Earls Court was perhaps even more rewarding. From a public relations viewpoint, contributions at boat shows or the Royal Agricultural Show provide an extremely valuable opportunity for staff to explain to members of the public some of the problems involved in producing forecasts and other services and more especially in having sufficient outlets for them. Such exchanges can only be of benefit.

As the Office gains more experience in arranging and staffing exhibitions many of the earlier mistakes are being rectified. The need to book space very early in order to have a good site is vital, but this was only appreciated after obtaining a poor position at Aberdeen in 1977. It is also important to order the required telecommunication lines from the Post Office several months in advance and to have as much contact as possible with MOD (DPF) and COI during the planning and construction stage to ensure that all details are considered. Even the choice of colours for the stand furniture can have a considerable effect on the general appeal of the display. The importance of having all the material ready well in advance and of having suitable standby material was underlined at Earls Court in 1978 when a model of Meteosat which was to have been the highlight of the stand failed to arrive from Switzerland where it was being displayed beforehand. This resulted in a hasty and not altogether satisfactory reorganization. Another lesson learned from experience has been the necessity for someone to arrive at the exhibition a day or so in advance to make contact with the engineers, the Post Office, the electricians and others, and to sort out the state of complete chaos that normally prevails at this stage. Problems such as the stand number being incorrect in the Exhibition Directory (as happened at Earls Court), or the wrong number of telephone lines having been installed can then be dealt with.

Exhibitions and other forms of advertising are essential parts of a commercial approach to the provision of services. This is particularly important in the offshore area where the Office is in direct competition with commercial firms who freely make use of material the Office issues to meet international obligations. There are other areas, for instance in the field of energy saving, where the services that the Office can provide are not as widely known as they should be. Exhibitions are a shop window to interest, inform and attract potential customers. Having done so, the business will continue at its present level and indeed expand only if the services provided are of the necessary quality, and meet the required specifications. This is the real challenge.

Reviews

Climate and man's environment, an introduction to applied climatology, by J. E. Oliver. 255 mm × 180 mm, pp. vii + 517, *illus*. John Wiley and Sons Inc., New York, 1973. Price £10.

Climatology has traditionally been the most popular part of meteorological science among geographers. The main reason for this no doubt lies in the deterministic thinking of such practitioners as Herbertson, Semple and Taylor, who suggested in the earliest years of this century that climate does indeed help to 'determine' the nature of human activity in any given place. Whilst deterministic thinking no longer occupies a major place in geographical study, the effects of climate upon human activity do appear to be taking on renewed importance in the corridors of power of both meteorological science and international politics. In the above context it is perhaps not surprising that at least half the books on applied climatology within the last decade have been written by geographers. The subject of this review is one such book. At this stage it is worth noting that the long delay since publication means that one is essentially reviewing the author's thoughts of nearly a decade ago.

The book comprises fourteen chapters grouped into three sections as follows: climate and environment; climate, man and man's activities; climates of the past and climatic change. In the first section the author essentially attempts to show the role of climate in the workings of other parts of the natural environment. Thus we have chapters on, for example: climate and geomorphology; climate and soils; climate, plants and natural vegetation. The section concludes with a review of climatic classifications. In section two the emphasis is on the more traditional aspects of applied climatology, concentrating upon physiological responses to climate, architecture, urban climates, agriculture, industry and transport. Section three is a brisk run through the evidence for, and theories of climatic change.

The tremendously wide scope of the book, a point stressed by the author in his introduction, may of course be, at one and the same time, a strength and a weakness. To the geographer much of the material will have been familiar since his schooldays and the treatment will seem to be rather superficial, particularly at any level above that of a first-year undergraduate. This criticism is more appropriate to section one than to the other two. To the professional meteorologist the material (particularly that in section one) may be less familiar and thus its superficiality may be less obvious. Indeed he may consider the breadth of the coverage to be the chief merit of the book. But both geographer and meteorologist would probably quibble with the inclusion in a book on applied climatology of a chapter entitled 'Theories of climatic change'.

Putting aside consumer preferences one or two general points should be made. Within the book the treatment tends to jump quite sharply from particular to general, from the didactic to the critical, and from exposition of technique to presentation of results. There appears to be a heavy dependence upon material that has already appeared in book, and even text-book form. A few of the diagrams (e.g. Figure 1.6) have no units on them and, as the publication date and place would suggest, units, where used, are non-SI. The main market for this book must be the geography students in North America. It may be success in that market that has persuaded the publishers finally to release the book in Britain. It faces stiff competition from the more limited and coherent books by Smith (1975) and Mather (1974).

B. W. Atkinson

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Mather, J. R. 1974 Climatology: Fundamentals and applications. McGraw-Hill. 412 pp.

Smith, K. 1975 Principles of applied climatology. McGraw-Hill. 233 pp.

Water Data 1977, by the Department of the Environment, Water Data Unit, Reading, Berkshire. 295 mm × 210 mm, pp. iv + 88, *illus.*, 1978. Price £2.20.

Water Data 1977 is the fourth in an annual series bringing together data from many sections of the Water Industry into a single volume. The layout is similar to previous editions of *Water Data*, one of which was reviewed in *Meteorological Magazine* (1979) Volume 108, p. 95.

The standard of presentation has been improved in the 1977 edition, with fewer clerical errors, and in some cases clearer diagrams. For example, some tables have been replaced by figures, which are more easily assimilated by the reader, and a greater number of the figures are now printed in blue as well as black and white for greater clarity and impact. In particular the graphs of groundwater fluctuations have been clarified by the use of a blue trace for the 'actual' water level, and by the use of larger lettering.

The major criticism of the 1976 edition was that the data were presented with inadequate explanations, thus preventing the average reader from fully appreciating the importance of the various sets of information. This criticism is valid for the 1977 edition as well.

The photographs are well reproduced, but lack explanations. This detracts somewhat from their value, although they make a pleasant interlude between the many tables and figures, which are the essential part of the volume.

As a reference work, it is of a high standard, providing a comprehensive and clearly presented catalogue of data from the various branches of the Water Industry. The series should be a valuable addition to the libraries of many organizations with direct or indirect links with water resources, hydrometeorology and hydrology.

C. A. Nicholass

Notes and news

Solar-cell experiments

Following a visit to Cyprus by a member of the Space Department, Royal Aircraft Establishment, Farnborough, arrangements have been made to carry out an annual two-week solar-cell experiment at RAF Akrotiri starting in July this year. A site has also been selected on Mount Olympus, Cyprus for a long-term environmental exposure test of solar-cell panels. The site has the advantages of high solar intensity with a strong ultra-violet content and a wide thermal variation between summer and winter.

Meteorological services in Malta

United Kingdom responsibility for meteorological services in Malta ceased on 31 March 1979. The first UK office with British staff was opened at Pieta in 1922, subsequently moving to Valetta in 1927. An observing office was opened at Luqa airfield in 1942 and forecasters were added to the complement in 1943. The Main Meteorological Office moved from Valetta to Luqa in 1946. The radiosonde station was established on the old Qrendi airfield in 1946 and was closed at the end of 1978. The last British staff left Malta on 28 March.

Reopening of forecasting office for the Royal Air Force

The observing and forecasting office was reopened at RAF Church Fenton on 28 March 1979, after having been closed in December 1974. A full operational program began on 2 April.

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It is requested that all books for review and communications for the Editor be addressed to the Director-General, Meteorological Office, London Road, Bracknell, Berkshire RG12 2SZ, and marked 'For Meteorological Magazine'.

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